CARE OF AUTOMOBILES

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A NON-TECHNICAL TREATISE FOR THE BUSINESS AND PROFESSIONAL MAN

By

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New York
Doubleday, Page & Company
1908

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SECTION I — HOW A GASOLINE MOTOR WORKS

There are many automobilists who have but a vague idea of the manner in which a four-cycle motor generates its power. The following paragraphs should make this matter perfectly clear.

The gasoline motor consists of a cylinder, a piston fitting closely in the cylinder and made practically air-tight by means of piston rings which fit into grooves in the piston and spring out against the cylinder wall. The cylinder may be likened to an ordinary pump and the piston to the pump plunger. The connecting rod is fastened on one end to the wrist pin which in turn is fastened to the piston. It is fastened on the other end to the crankshaft.

When the crankshaft is revolved it works the connecting rod and piston up and down in the same manner that the pedal of a bicycle works your leg up and down when running down grade.

In the cylinder head or top portion of the cylinder are placed two valves which when closed are gas-tight. One of these valves is called the inlet valve, the other being the exhaust valve. Both of these valves are opened at predetermined intervals by a camshaft connected with and revolved by the crankshaft. The camshaft is a rod of small diameter on which are placed cams or small metal projections. When the camshaft revolves these cams or projections come underneath or above stems attached to the valves and open them.

The inlet valve is connected by a pipe, which fits over the cylinder opening with the carburetor, which is the device for converting the liquid gasoline into an explosive mixture of gasoline vapor and air. The burnt gases are forced through the exhaust valve out through the exhaust opening into the muffler or silencer and thence to the open air.

We will now revolve the crankshaft by turning the starting crank. As this shaft starts to turn the piston is pulled downward in the cylinder. As the piston is gas-tight a powerful suction ensues. The camshaft at this *suction stroke* has opened the inlet valve so that the piston sucks in a highly explosive mixture from the carburetor through the inlet pipe.

When the piston has been drawn down as far as it can go it has sucked a cylinder full of gas. At this instant the projection or cam on the camshaft has passed from under the stem of the inlet valve, allowing a strong spring attached to the valve stem to shut the valve tight.

The crankshaft makes a further half-revolution and the crank begins an upward movement, driving the piston to the top of the cylinder.

As before stated the cylinder has taken in a full charge of gas and the valves being closed it is held. The piston being gas-tight compresses the gas on the upward stroke. When it is at the top of this *compression stroke* an electric spark occurs in the spark plug. This spark ignites the highly compressed gas and an explosion takes place in the cylinder. By force of this explosion the piston is driven to the bottom of the cylinder, causing the connecting rod to turn the crank on the crankshaft.

In the one-cylinder motor there is but one crank; in the four-cylinder motor there are four cranks turning.

The explosion being very powerful, not only forces the piston down, but gives it impetus enough to come up again, go down again, and rise once more. The heavy fly-wheel helps to accomplish this, at the same time smoothing out and absorbing the shock of explosion, otherwise the motor would soon tear itself to pieces.

The fly-wheel on a one-cylinder engine is large and heavy, as there is but the force of one cylinder and the fly-wheel must help to keep the crank turning, while on a four or six cylinder engine the fly-wheel can be made small and

light as with so many cylinders the explosions overlap each other, resulting in a continuous flow of power. The fly-wheel then serves only the purpose of a governor.

When the explosion or *power stroke* has driven the piston down to the bottom of the cylinder, another cam revolved by the camshaft lifts the exhaust valve, so that when the piston rises, owing to the expended force of the explosion, it expels the burnt gas through the open exhaust valve out to the muffler. When the piston has risen to the top of the *exhaust stroke* the cam passing from under the stem of the exhaust valve allows the spring to close the valve in the same manner as the inlet valve was closed, and the inlet valve is opened just as the piston is starting downward again, resulting in a fresh charge of gas being sucked into the cylinder.

In a two, four or six cylinder engine these identical operations are taking place in each cylinder, the up and down motion of the various pistons being changed into a turning movement by the crankshaft.

The electric spark is caused in the spark plug at exactly the right moments by the same camshaft which opens the valves.

The first revolving of the crankshaft, as before stated, is accomplished by turning the starting crank. After the first explosion the motor continues running by force of that and succeeding explosions.

This type of gasoline motor is known as the four-stroke or four-cycle motor and the respective strokes are the suction, compression, power and exhaust.

Naturally a great heat is generated in the cylinders by the explosions. To keep the temperature down a water jacket or hollow space around the cylinder is provided. Cool water is kept constantly circulating through this space by means of a water pump driven by the engine, the water being cooled by a radiator and fan.

The two-cycle motor works on practically the same

principle except that an explosion takes place every revolution or rising of the piston instead of every two revolutions or two risings of the piston as in the four-cycle type.

SECTION II — CARE OF THE GASOLINE MOTOR

Pistons and Cylinders.—In order to keep the cylinders in the best working condition they should be thoroughly flushed through the compression-relief cocks or spark plug holes with kerosene every week or two. The kerosene cuts the carbon deposit from both cylinder and piston, causing the piston rings to spring tightly against the cylinder wall, thereby improving the compression and preventing overheating and premature ignition. The motorist should begin this flushing treatment early, however, as after a time the carbon hardens so that it can only be removed by taking out and scraping piston and also cylinder wall.

Each time the piston is removed the cylinder should be inspected. Run the hand over its bore and see that it is perfectly smooth. It may be found to be so scratched as to need re-boring. Running without oil will score the cylinder, as usually will the sharp ends of a broken piston ring. Another cause is the lateral motion of a loose wrist pin.

In having the cylinder re-bored intrust it to no one but a thorough mechanic and a machine shop of full and perfect equipment.

Crankshaft, Camshaft and Connecting Rods.—Provided these are of good design they should occasion no trouble.

Valves.—Owing to the intense heat of the cylinder, valves become pitted and do not fit their seats perfectly, causing a loss of compression. To make the valve fit perfectly it is necessary to grind it in its seat.

The valves should be ground about twice a season if the car is given the average amount of running, but under every-day conditions they need but very little attention. When grinding valves, it is best to take off the inlet and exhaust pipes, as this will enable you to thoroughly clean

out the valve seats and openings so that there will be no chance of particles of the grinding mixture being sucked into the cylinder and causing trouble afterward. After removing the pipes, the valve spring should be compressed in order that the key may be pulled out of the valve stem. (A tool known as a valve-lifter is generally used for this purpose.) After the valve caps have been removed with a socket wrench, the valves are easily lifted out.

Make a soft paste of No. 120 Carburundum and cylinder oil and after rubbing a little of this mixture on the bearing surface of the valve, drop some on the valve seat. Press a screw-driver lightly in the slot on top of the valve and give it a rotary motion backward and forward. After doing this on one spot for a short time, lift the valve just clear of the seat and turn about one-third of a revolution, repeating the grinding operation. Continue whole operation for several minutes, replenishing the supply of paste as it becomes rubbed off the seat.

After the grinding, clean the valve opening and valve seat thoroughly with gasoline, being careful to wipe off every little speck of the grinding mixture. If the whole surface is not bright, continue grinding.

Bearings.—The bearings of a gasoline motor should always be kept in proper adjustment. Otherwise a speedy deterioration of the motor will result. Knocking in the motor may be of course due to any one of a number of causes, but a decided knock at high speed indicates loose connecting rod bearings. To remedy this remove lower half of crank case and take up or tighten up the bearings. Between each bearing (in most engines) thin strips of metal of varying sizes called shims are inserted in order to allow for wear on bearings. When taking up bearings, it will probably be necessary to remove one or two of these shims from *each* side of the bearing. When one of these shims is taken from each side of the bearing and the nuts tightened, the bearing naturally fits tighter on the shaft. The

bearing should always fit snugly and without play but not tight enough to bind, thus allowing for expansion. When unable to move bearing sidewise by lightly tapping it with a hammer there is a bind. It may be necessary to substitute paper shims in place of the metal shims in order to secure proper adjustment.

The main bearings do not require adjustment as often as do the connecting rod bearings. Once a season is generally sufficient.

A noisy cam shaft usually indicates a looseness of the camshaft bearings which should be taken up at once. These are usually adjusted by simply tightening a screw.

SECTION III — ENGINE TROUBLES ON THE ROAD

One of the great secrets of economical motor-car operation lies in watching the car while on the road. If the motorist familiarizes himself with the usual running sounds and general behavior of the car, any unusual developments may be instantly detected, thereby forestalling serious trouble and consequent repairs and expense. Observation of this sort is soon involuntary, so to speak, and the driver becomes so much in sympathy with the whole mechanism as to notice any discord just as the rider of a spirited horse would detect a slight ailment.

The following paragraphs cover all engine troubles that would ordinarily be experienced on the road:

1. Misfiring.—In a multiple-cylinder motor, no cylinder should be allowed to skip or misfire for any length of time, as this imposes an irregular strain on the crankshaft.

In order to determine which cylinder of a four-cylinder motor, for instance, is missing, first cut out three of the four cylinders by depressing their coil vibrators. Supposing these first three cut out are cylinders, 1, 2 and 3. Now if the engine continues to run, cylinder 4 must be working properly. Now cut out cylinders 1, 2 and 4 to discover if 3 is working, then cylinders 1, 3 and 4 to see if 2 is working, and finally cylinders 2, 3 and 4 to determine if 1 is working. In a three or six cylinder engine, a similar process should be followed to detect the missing cylinder.

Another means of detecting a missing cylinder is to open the compression petcocks one after the other. The one that does not show flame is not firing. When the faulty cylinder has been discovered, the spark plug should be removed and laid sideways on the cylinder so that only the

case is in contact, thus completing the circuit in the same manner as if the plug were in the cylinder. On cranking the motor a spark should jump between two points. Failure of the spark to appear indicates a break or short circuit in the plug. The remedy of course is a new plug. Should the spark points of the plug be too widely separated, the plug will not spark. The remedy is to bring the points nearer together, the proper distance being a "full" 1-32 inch.

A sooted plug due to the carbonizing of oil or gasoline will prevent a spark by allowing the current a path of less resistance than that of the air gap between the plug sparking points. If on examining plug, the points and lower parts of the insulation are covered with a sooty deposit, it should be soaked in gasoline and cleaned with a stiff brush, thoroughly removing all soot. (See Section VII.)

If after adjusting the old plug and trying a new one the spark still does not occur, the cause of trouble may be a short circuit in the primary or secondary wiring.

The batteries should be thoroughly gone over. Sometimes a wrench or screwdriver inadvertently left on the batteries is the cause of a short circuit. Follow the primary wires to the coils and make sure that the wire insulation is perfect. A primary short circuit will rapidly deplete the batteries. Wind tape around any worn insulation. A short circuit is not so apt to occur in the secondary system as the wires are heavily insulated; however, a short circuit in this system is easily detected as the vibrators will continue buzzing and the induced current usually sparks where the short circuit is disturbed. A broken secondary cable should be replaced by a new one.

Misfiring may be due to loose connections of wires at the binding posts in either primary or secondary circuits. Upon the looseness of the wires depends the degree of interference of current.

Another frequent cause is weak batteries, especially

at high speed. A run-down battery is sometimes able to supply a spark at slow speeds for some little time, but as the speed increases the battery is unable to furnish hot sparks with the necessary rapidity.

Misfiring is also caused by a defective mixture whether too rich or too weak. The ignition in either case is slow, if it takes place at all.

A leaky valve will cause misfiring by not allowing a sufficient compression to cause an explosion, as will also a leaking inlet manifold.

2. Firing in the Muffler.—This is commonly caused by misfiring, the unexploded charges passing into the muffler and being ignited there by the exhaust of the cylinder or the heat of the muffler walls. This produces a violent explosion but does no particular harm. Back-firing, often confused with firing in the muffler, is a back-kick of the engine when it is cranked with an early spark.

3. Overheating.—This trouble may result from faulty lubrication or a defect in the cooling system. (See Section X.) If the radiator is comparatively cool and the engine overheating, it is safe to say that the pump is not working or that the radiator needs refilling. If the water circulation has been found to be working properly, the trouble is no doubt with the cylinder lubrication. If the oiler has a sight feed device see that it is dropping the required number of drops. If on stopping the motor the engine cranks with difficulty, it is probable that the oiling system has become clogged, in which case a thorough inspection should be made. Hardened carbon deposits on piston will cause overheating by preventing radiation.

4. Faulty Compression.—Loss of compression may be detected by cranking motor. If the usual resistance is not present there is a loss. The losses may occur at any of the following points—the valves, valve caps, piston rings and the spark plugs.

Leaking Valves.—After a month or two of running the bevel face of the valve is apt to become pitted and its seat covered with a carbon deposit. The valve will then fit loosely, allowing part of the compression to escape. The remedy is to grind the valve. (See Section II.)

Leaking Piston Rings.—A continued use of too much oil often causes the piston rings to become gummed and to stick tight in their grooves. The rings then do not spring tightly against the cylinder wall and compression is lost. Hissing in the cylinder when the motor is cranked is indicative of this trouble. Flushing the cylinder with kerosene oil and then cranking the motor for a few seconds will free the piston rings. Draw off kerosene by opening petcock on bottom of crank-case. Sticking of piston rings will never occur if the motor is periodically flushed after the manner described in Section II.

Spark Plug and Valve Cap Leaks.—Leaks in the spark plug or valve cap may be detected by squirting some oil around the joints, while the motor is running. The oil will bubble up or be blown away according to the magnitude of the leak. A leaking spark plug should be replaced by a new one. See that plugs and valve caps are screwed down tightly and kept so.

5. Knocking in the Cylinder.—Knocking is a tapping or in aggravated cases pounding in the cylinder. Knocking may be caused by any of the following derangements. 1. Early Ignition; 2. Loose Bearings; 3. Improper Lubrication; 4. Loose Fly-wheel; 5. Broken Piston Rings; 6. Self-Ignition; 7. Defective Mixture. A process of elimination will determine the seat of trouble.

Ignition Knocks.—Knocks caused by early ignition usually manifest themselves when the car is ascending a hill and slows down under load. The remedy lies in retarding the spark just enough to cause the knock to cease.

Loose Bearing Knocks.—This is a continuous knock occurring at the instant of explosion. It is a very harmful

practice to let a knock of this sort run along without attention as is often done. In order to detect a loose crank pin bearing knock, depress the vibrator, cutting out the first cylinder and note result. If the knock still persists, it is not caused by the crank pin bearing, as when the cylinder is not firing a crank-pin knock would cease, there being no force of explosion to cause it. Test each cylinder in the same manner. If the knock persists throughout the test, the trouble is probably with the camshaft or main bearings, necessitating a removal of the lower half of crank case.

Improper Lubrication Knocks. — Defective lubrication will cause the cylinder to overheat and the piston to seize. This knock is very pronounced and develops rapidly. The motor should be stopped instantly and the oiling system inspected. It is usually recognizable by the accompanying overheating of the cylinder.

Loose Fly-wheel Knock.—This rarely occurs in carefully constructed cars. A loose fly-wheel may be detected by placing the hand lightly on the rim, any wobble being instantly felt.

Broken Piston Ring Knock.—This trouble causes more of a clicking sound than a knock, and is sometimes indistinguishable. If the engine is inspected at regular intervals, trouble of this sort is not likely to become serious.

Self-ignition Knock.—This is caused by an excess of oil carbonizing in the cylinder head or on the piston. This becomes incandescent and causes premature ignition. The resulting knock is not very pronounced and sometimes the trouble is only manifest by the motor continuing to run with the switch thrown off.

Defective Mixture Knocks.—Different spark positions must be maintained for different mixtures. A spark position might be correct for an over-rich or weak mixture, owing to both these mixtures igniting slowly, and cause a

knock if the mixture were perfect—as a perfect mixture would ignite instantly.

Squeaking Sounds.—Squeaking in any part of the car is a sure sign of faulty lubrication. In the cylinder, however, knocking and seizing would be the result of poor lubrication.

Hissing Sounds.—These usually denote loss of compression at some point.

Failure to Start.—If a motor refuses to start after a reasonable amount of cranking, further exertion is useless and the cause should be sought out. The method of procedure should be a process of elimination. First, be sure the gasoline tank is full and the valve open. Second, see that switch is on. Third, if the motor still refuses to start and the weather is cold, a weak mixture is the source of trouble. This may be remedied by tickling the carburetor. Pour some gasoline in each cylinder, if weather is extremely cold. Fourth, test batteries for strength. (See Section VII.) Fifth, if the electrical system does not work after batteries have tested properly, look for a short circuit or loose connections. Sixth, make sure that vibrators are adjusted properly. Seventh, test spark plugs, and if the plugs are found to be perfect and the vibrators are buzzing yet no spark appears, there is a short circuit in the secondary wiring. Eighth, see that there is no clogging in the carburetor due to a stopped vaporizing nozzle or needle valve. Ninth, make certain that the oiler is doing its work. This procedure should locate the seat of trouble.

Running Down.—The same process of elimination as recommended for failure of the motor to start should be used to discover the cause of a motor gradually slowing down and stopping.

SECTION IV — CARBURATION AND CARBURETOR TROUBLES

Carburation is simply the process of changing liquid gasoline into an explosive gas and the function of the carburetor or vaporizer is to rapidly bring a quantity of air into contact with a quantity of gasoline in the form of a spray in unvarying proportions, the evaporation of the latter forming an explosive gas which is introduced into the cylinders of the motor. The problem of carburetor is to supply the motor with an even and uniform mixture at all engine speeds, that is at all points of throttle opening. Were the motor always run at a constant speed and under a constant load the problem of carburation would be simple indeed.

The Float Feed Carburetor.—The gasoline is sprayed or atomized through a nozzle with a needle-like opening by the suction of the motor, the spray or mist mixing with a certain quantity of air. When the needle valve regulating the liquid supply is correctly adjusted the air will be nearly uniformly saturated with such a proportion of liquid as to render it very explosive, whether the motor is running fast or slow—if it is running at slow speed the suction will be slight and the spray will be accordingly light while at high speed the suction will cause the nozzle to spray vigorously.

It is a fact, however, that this self-regulation is not perfect, for at high speeds the carburetor usually produces a mixture containing too much gasoline. This kind of carburetor is termed a simple or hand-regulated carburetor and one provided with an auxiliary air valve admitting more air as the engine speed increases, thus preventing this tendency to produce rich mixtures, is termed an "automatic" or "compensating" carburetor.

There are two methods of governing the float feed

carburetor: First, by throttling the mixture by varying the amount of air passing through the air supply valve; second, throttling the volume of a mixture which has been predetermined by permanent adjustment, by regulating the opening of fuel supply valve to the motor. The second method is the method universally used.

Having acquainted the reader with the form and theory of the carburetor, the discussion of carburetor troubles will be taken up.

In the first place the modern carburetor is a device of delicate adjustment. The motorist should never re-adjust or experiment with a carburetor that is working satisfactorily. It may be well for a gas engine expert to do this but the average motorist will find himself in a maze if he attempts to improve upon a correct adjustment. Nothing affects the engine so quickly as a carburetor out of adjustment.

Cold and the Carburetor.—Cold greatly affects the action of the carburetor. Upon starting the motor in cold weather it will usually run stiffly, skipping now and then. Let the carburetor alone—simply allow the engine to warm up. It will then run smoothly.

Stoppage of Gasoline Flow.—This annoyance is experienced with more or less frequency and often the motorist fails to locate the seat of trouble. To minimize occurrences of this sort all gasoline should be strained through a chamois filter when filling the gasoline tank. This filter serves a double purpose; catching any particles of dirt and excluding all water which the gasoline may contain. When the gasoline refuses to flow, the first step to take is to see that the wire gauze filter, generally placed in the supply opening of the float chamber, is thoroughly cleansed of impurities. If, upon replacing filter, the gasoline still refuses to flow, a particle of dirt has very likely lodged in the needle valve regulating the gasoline supply from the tank.

To remove this obstruction, first screw down needle valve tightly, being careful to count the number of revolutions so that the original adjustment may be secured. The object of this procedure is to crush the dirt particles. Next unscrew needle valve a few turns and flush out its seat by "tickling" the carburetor (depressing the float). This operation consumes but little time and effectively disposes of the obstruction. Draw off the float chamber occasionally to insure against dirt collecting and getting into the carburetor passages. These operations should cause the gasoline to resume its normal flow upon depressing the float. Should there still be a stoppage or feeble flow the filter sometimes fitted to the tank outlet should be cleaned. A source of trouble that is not readily thought of is a loose gasoline shut-off cock. The vibration of the car and road shocks causes this cock to slowly turn, finally shutting off the gasoline supply completely. A tightening of the cock is the obvious remedy.

Freezing of the Carburetor.—This is caused by the presence of water in the float chamber. The water settles in the bottom of this chamber, interfering with the action of the float. A hot water application followed by a draining of the float chamber will put things to right.

Water in Gasoline.—When the engine starts, runs fitfully or irregularly and finally stops, this is very apt to be the trouble. A simple means of ascertaining the presence of water in gasoline is to place a few drops of gasoline on a coin or piece of metal and if the gasoline evaporates and leaves the metal dry there is no water. Any water would remain on the metal.

Choked Vaporizing Nozzle.—This trouble can often be remedied by flooding the carburetor or speeding the motor. The flooding washes away the obstruction and the speeding carries it away by suction.

Loose Pipe Connections.—Should the intake pipe not fit snugly, the mixture would be diluted, causing the

motor to skip. Look after these connections at frequent intervals.

Flooded Carburetor.—This trouble may be caused by (1) a sticking of the float, (2) a cork float becoming too heavy, (3) a punctured metal float or (4) a leaking needle valve.

1. Sticking of the float is easily remedied by unscrewing cover to float chamber and freeing the float.

2. A cork float, after being used for some time, absorbs a quantity of gasoline and consequently increases in weight with the result of maintaining the gasoline level in the float chamber above the level of the top of the vaporizing nozzle. This means a constant loss of gasoline when the car is idle. The remedy in this case is to decrease the weight of the float, until the gasoline is flush with the top of the vaporizing nozzle.

3. A punctured metal float may be detected by shaking it. If it contains gasoline it is perforated. Such perforations are usually very minute and sometimes may only be detected by heating the float and testing it with a match, the hole being detected by ignition of the issuing vapor. When the hole has been found enlarge it a trifle so as to allow all gasoline to pass out. Then solder hole, being careful to use only enough to stop leak, otherwise the float would be made too heavy.

4. If the float is found to be empty, no doubt the needle valve or valve in carburetor automatically shutting off gasoline supply is leaking. This valve consists of a small passage in the bottom of the float chamber. A steel pointed needle fits in the passage, the stem of the needle passing up through a central passage in the float chamber. To this stem is attached a small toggle lever which begins to press upward as the float rises in the chamber. When the gasoline has reached a certain level in the float chamber, the toggle lever presses up enough to depress the needle and hold it on its seat, thereby pre-

venting any further flow of gasoline. As the engine sucks the gasoline from the vaporizing nozzle, the level of the gasoline in the float chamber falls and the float falling with it raises the needle valve and admits more gasoline. Now this needle may not close tightly owing to a particle of grit or a slight rusting through water in the gasoline. To properly seat it again it must be ground in just like an ordinary valve with a little No. 120 Carburundum made into a soft paste with the aid of some cylinder oil. On some carburetors this value is bevel seated similar to the inlet and exhaust valves of the engine.

Needle Valve Adjustment.—This adjustment or regulation of the flow of gasoline is common to all carburetors. To secure proper needle-valve adjustment, the ignition system must be in perfect working order. See that the batteries are fresh and strong and the tremblers on the coil correctly adjusted. Test the spark by removing plug —it should be fat and hot. Next open muffler. Advance spark four or five notches on the arc and open throttle enough to speed motor easily. Flood carburetor and make sure the gasoline supply valve is wide open. Then open needle valve a quarter or half turn and crank motor. Allow motor to run for a minute or two so as to burn away any excess of oil. Now speed up motor by advancing both spark and throttle levers (one person should attend to this while the other is engaged in adjusting the needle valve). If there are explosions back through the carburetor when the motor is speeded up, it indicates a weak mixture, that is, not enough gasoline for the amount of air flowing through the pipe. In this case open needle valve a little more, but if the engine will not speed up to any extent yet does not give carburetor explosions, it is safe to say that the needle valve must be screwed down slightly because the mixture is too rich. A rich mixture may be also detected by black exhaust smoke, the sound of the exhaust being rather muffled. When the mixture is

correct the sound of the exhaust is sharp and full like the report of a revolver. A small pale exhaust flame indicates too much air in the mixture. This may be demonstrated by the air mixer on an ordinary gas stove.

Automatic Carburetor Adjustment.—The adjustment of this type of carburetor varies greatly and the safest and most practical means of securing correct adjustment is to follow the accompanying instructions. Generally speaking, the adjustment of the needle valve in an automatic carburetor should not be changed in order to make the motor run slowly.

SECTION V — CLUTCH TROUBLES AND THEIR REMEDIES

The multiple-disc and cone clutches seem to be the types in general use to-day.

The multiple-disc clutch consists of a series of metal discs secured alternately to the crankshaft and to the driving shaft. When the clutch is let in a spring presses the discs together, making a gradual contact. Some multiple-disc clutches run in an oil bath while other types use no oil, facing one series of discs with leather.

The cone clutch consists of two members. The first or female member is the fly-wheel itself, the rim being dish-shaped so as to afford a tight seat for the second or male member which is made to fit in tightly by means of a powerful spring.

There are two types of cone clutches: the external cone clutch in which the first member is forced against the fly-wheel from the rear and the internal or self-contained clutch in which the male member is contained within the fly-wheel and the contact made from the front. The latter is generally preferred as it affords protection against oil or grit. The contact is leather to metal or fibre to metal.

CLUTCH TROUBLES

Multiple-disc and cone clutches are subject to three varieties of derangement—gripping, spinning, and slipping. Gripping consists of a quick, sharp engagement of the clutch. The power is thus applied suddenly, imposing a great strain on the transmission system. A clutch, properly designed, should slip at first and take hold as the speed of the car increases. Gripping may be caused by looseness in the foot pedal or operating level joints or a "give" in the levers or fulcrum. A gradual clutch engagement cannot be secured when the leverage is not ab-

solutely positive. Another cause is a too powerful spring tension. A proper spring tension should allow a slight slipping of the clutch when ascending a steep grade on high speed.

In a leather to metal contact, gripping may be caused by an exhausting of the oil in the leather, thereby roughening its surface. Water or gasoline should not be allowed to come in contact with the leather, as they will dry up the oil that keeps the leather in good condition. The oil may be also dried out by frictional heat, so a careful inspection of the condition of the leather should be made at intervals of one to two months. Use a good clutch leather dressing when the leather shows signs of roughening. Machine oil, however, should not be used, as it is not readily absorbed by the leather. It is important to rub in the dressing evenly, if an even engagement is to be secured.

Spinning or continued revolution of the driven member, which is very harmful to the gear teeth, is usually caused by faulty design, poor adjustment, failure to make a complete disengagement of the two members. This latter fault can be traced to improper lubrication, an adjustment which does not allow of a movement sufficient to separate both members or a too tight clutch shaft bearing causing binding between the members.

The driven member should be tested while the car is running on the road to ascertain whether or not it stops instantly. If it does not, there is cause for immediate investigation.

A slipping clutch may be due to weak spring tension or presence of oil or grease on either surface. The remedy for the former is obvious. In the latter case do not use gasoline to remove the oil, for gasoline, as before stated, dries up the leather. A good method is to dry up the oil by means of a dusting of finely powdered chalk.

Another cause of slipping is through the wearing of the corks or leather on the discs or cone of the clutch,

the clutch pedal will gradually move backward until it rests against the rear end or slot in the floor. If left in this position, it would in a short time slightly release the clutch, causing it to fail to hold properly or to burn out. To avoid this, the lever should be readjusted when it worked so far back that it touches the slot, even but slightly. Loosen the pinch binder on the lower end of the lever and move lever forward a little, then tighten pinch binder.

SECTION VI — CARE OF TRANSMISSION AND DRIVING MECHANISM

Sliding and planetary gear transmissions are the two universal types. Transmissions require but little care. If the sliding gear is used see that the rim of the large gears always dips into the oil. Always make the change of gears as quickly as possible to avoid any possible burring of gears.

In the planetary system see that the tension of the straps is such as to be free from slipping on each speed as well as from dragging when released.

Driving Mechanism.—Two methods of transmitting the power to the rear wheels are in general use—chain and bevel gear drive.

The single chain drive is usually employed on runabout or light touring cars and the double chain on heavy touring cars.

Tension of Chains.—Keep the chain at such a tension as to hold it in two straight lines between tops and bottoms of sprockets when the car is idle. Too tight a chain increases wear on both chain and sprockets and causes loss of power. On the other hand, should there be too much slack, the chain would be apt to jump off under road shocks.

Cleansing of chains.—Chains should always be cleaned when they develop a grinding or snapping noise. Continuous running in wet and muddy weather necessitates frequent cleaning. Over dry roads chains need much less attention. To clean a chain thoroughly, first remove it and place it in a pan of gasoline. The grease and grit which accumulates between the inside and outside links and on the pins may be best cleaned with an old tooth brush. Rinse chain in fresh gasoline and wipe dry. Prepare a

bath of melted tallow and graphite; one part graphite and seven parts tallow. Keep bath at a temperature of about 350 degrees F., so as to prevent it from hardening. At this temperature, it is very thin so it will enter into all bearings of the chain, carrying the graphite with it. The bath should be of about twenty minutes duration. Then remove chain and hang it up to drain. The tallow and graphite preparation may be purchased ready mixed if the motorist so desires. Warm oil is the best substitute for the tallow-graphite bath.

Another method of cleaning which can be easily accomplished while on a tour without removing chains is as follows: See that gear lever is in neutral. Then jack up rear wheels and throw in the reverse, which will turn the wheels as slowly as possible with the motor. Now squirt gasoline on the moving chains, cutting the grit and dirt from top and bottom of chain. When the chains seem thoroughly cleaned with the gasoline, stop motor, shifting back to neutral. Now, turning wheels with one hand, apply a thick grease with the other. Force the lubricant between the rollers and side link by squeezing the hand. Wipe off superfluous grease. This manner of cleaning is not so thorough as the first mentioned method but is very convenient where the chains can not be removed and cleaned properly.

Pitch of Chains.—The wearing of the chain causes a variation in pitch, which increases wear on sprockets. Replace chains before they have damaged sprockets to any extent, otherwise new chains will not fit perfectly and run quietly.

Shortening Chains.—This may be done by bending out every other pair of side plates by means of a chisel tapering at the sides or any other similar piece of metal. Care should be taken not to drive the chisel in between the plates too far, as it would result in breaking the rivets.

An early adjustment of chains may be expected to be necessary with a new car.

Examine small sprocket frequently, as owing to its size it wears quicker than the large sprocket. Do not run with a worn sprocket. Repair or replace it.

Every motorist should own a pair of chain pliers. These pliers will hold the chain at any place, thus permitting free use of the hands to connect the links.

Bevel Gears.—Bevel Gears being dirt and dust proof occasion little or no trouble.

SECTION VII—IGNITION TROUBLES AND THEIR REMEDIES

Ignition Systems.—The electric spark is the universal method of igniting the charge. There are two systems of ignition—the make and break or low-tension system and the jump spark or high-tension system. The jump spark, however, is in almost universal use in America.

Both systems are effective. The make and break system is electrically simple and mechanically rather complicated, while the jump spark system is electrically complex and mechanically simple. It will be readily seen that popularity of either system is due to individual taste as much as relative efficiency.

In the make and break system the primary current passes through a reaction coil and produces a low-tension spark by means of mechanical contact, no timer being required. In the jump spark system the primary current is passed through an induction coil producing a high-tension secondary current which passes or jumps between two slightly separated points in the spark plug.

Sources of Electrical Energy.—The electrical current is derived from five sources: (1) Primary or dry cell batteries, (2) Secondary or storage cell batteries, (3) Low-tension magnetos, (4) High-tension magnetos and (5) Dynamos.

A dry cell battery usually consists of six or eight open-circuit cells and generally two such batteries are included in a car's outfit so that each battery can be given a rest at intervals or both wired up together in case of emergency.

The storage battery or accumulator usually consists of three or four cells in hard rubber jars, electrically connected and carried in an acid-proof case. This type of battery is charged by a dynamo furnishing a direct current and unlike the primary cell it may be recharged when

the current is exhausted. An accumulator is termed a secondary battery but this does not mean that it furnishes a secondary current.

Low-tension magnetos are furnished with cars using make and break ignition. These deliver a low-tension primary current.

High-tension magnetos are used with the jump spark ignition system. The current delivered is a secondary high-tension current, the magneto itself transforming the primary current by means of high resistance winding. This magneto, then, is a generator, induction coil and distributor combined in one working whole.

Small dynamos are used with either system. In the high-tension system the dynamo current must be transformed by the induction coil.

The timer is a device for opening and closing the primary circuit of the high-tension ignition system. The timer determines the exact point of explosion in the cycle of the engine and permits of varying this point any time while the engine is in operation.

Timers vary greatly in construction, but every timer consists fundamentally of a stationary part and a rotary part. The rotary part is driven from the engine at one-half the engine speed. In a two-cycle motor, however, it is driven at full engine speed. The stationary portion of the timer is provided with contact rollers or blocks, equal in number to the cylinders of the motor, and the rotary part is so constructed that it can pass over and make contact with all the contact rollers in one revolution.

The operation of the timer is as follows: The stationary portion of the timer is so arranged that it may be rocked backward and forward. Now if this part is turned from a set position (which position is as far as the spark may be efficiently retarded) in a direction opposite to the motion of the rotary contact cam or brush, this cam will

strike the contact rollers earlier, which causes the spark to occur in the cylinder earlier. If the stationary part is turned in the same direction as that of the rotary cam, the contact will be later and the spark retarded.

Timer Derangements.—The contact surfaces wear after a period of use, affecting the timing. A readjustment of the timer is then necessary.

If the contact points are platinum pointed, their surface will become rough and non-conducting after extended use. This trouble can be remedied by filing the contacts clean and smooth. See that the two points meet squarely. Some platinum points are so hard that a file does not clean them properly. In this case use emery cloth.

See that the timer is perfectly firm and secure on its shaft. If it wobbles, it will very likely occasion trouble.

Keep timer contacts free from dirt and gummed oil. Either of these may interrupt the current altogether. Some motorists pack the timer in vaseline with excellent results.

Always see that timer binding posts are screwed down tightly and that the contact between roller or block and rotary cam is strong.

The Coil Vibrators.—The office of the coil vibrators is to interrupt the primary current with great frequency, thereby producing in the spark plug a series of hot sparks.

Vibrator Adjustment.—The motorist should accustom himself to the sound of the vibrators when they are working properly. He will then be able to adjust them by means of "tuning." To properly adjust the coil by this method, screw up or down the adjusting screw controlling the tension of the trembler until a sharp steady buzz is heard and then secure this adjustment by means of tightening the set screw which locks the adjusting screw. A further adjustment can be made by speeding up motor

and so adjusting the vibrator tension that the maximum engine speed is obtained. In a multiple-cylinder motor, one vibrator should be tested at a time by holding the others down.

When the platinum points on either vibrator or adjusting screw become pitted, the vibrator will usually stick and no spark will occur at the plug. The remedy is to clean them with a smooth file, being careful, however, not to overdo this operation.

If the adjusting screw is turned down more than is needed, thus increasing the vibrator tension, the consumption of current will be very heavy and the platinum points will burn away quickly.

If the car is left standing in the rain it is advisable to cover the coil box with a rubber coat or lap robe so as to prevent the water from striking the coil box where it might penetrate the coils and cause a short circuit.

The Spark Plug.—Spark plugs are made in endless varieties but the essential parts of any spark plug are first, a metal shell which fits into the combustion chamber of the cylinder, second, a hollow bushing of insulating material fitting inside the shell, and last a metal rod fitting in the hollow bushing. At one end of the rod there is a discharge terminal or sparking point and at the other end a binding post or means of holding the secondary cable.

Failure of Insulation.—Cracking of the insulation allows the current to discharge through the crack. Cracking is usually confined to porcelain plugs. Cement-filled plugs are apt to become oil-soaked and so lose their non-conducting property. Mica plugs often contain metallic impurities causing a short circuit. In any of these cases a new plug is the remedy. Other spark plug troubles are treated in Section III, as are also Wiring Troubles.

SECTION VIII—CARE OF BATTERIES

Keep all binding posts and wire ends free from dirt or corrosion. See that connections are kept tight.

When the dry batteries run down as low as six amperes, they should be replaced by a new set, as ignition trouble is liable to be caused by weak batteries.

Dry cells can be stimulated for a short period by boring a hole in the wax and pouring in a little vinegar or simply water.

Extra mileage can be secured from two run-down sets of dry cells by wiring them in parallel, using but one side of the switch.

Use the ammeter for testing dry cells. Make the reading as quickly as possible so as not to weaken cell. The average dry cell (2 1-2 in. x 6 in.), should test about 20 ammeters at the time of purchase. When purchasing dry batteries always test with *the ammeter,* as an exhausted cell will register almost the same *voltage* as a new cell. The voltage of the 2 1-2 in. x 6 in. cell is about 1.5.

Storage battery manufacturers usually send out complete instructions as regards the care of the battery, however, the following suggestions cover the essential points of care-taking.

A storage battery consists of a positive set and a negative set of lead plates immersed in an electrolyte of dilute sulphuric acid. The positive set is lead containing peroxide of lead, the negative set being pure lead. When fully charged the positive plates are brown in color and the negative plates gray.

See that plates are covered with the electrolyte. When mixing the electrolyte, pour acid into water, not water into the acid.

Do not discharge battery below 1.8 volts per cell when current is flowing.

Charge the battery in the right direction, that is, have the positive wire of the direct current connected to the positive terminal of the battery and the negative wire with the negative terminal.

Be very certain that the charge is complete.

Do not allow the temperature of the electrolyte to rise above 100 degrees F. when charging.

The battery should be charged once every two months whether it is used or not.

Never bring a naked flame near the openings in the top of the battery during or immediately following charge, as inflammable gases are then given off.

Adjust the specific gravity only when absolutely necessary and never when the battery is not fully charged. Adjusting the specific gravity consists in diluting with water or adding sulphuric acid to the electrolyte to maintain the required specific gravity which varies in different types of batteries from 1.200 to 1.250. Be very careful in this matter as the life and operation of the battery is greatly affected by the condition of the electrolyte.

If a sediment appears near the plates the jar and plates should be washed carefully and reassembled. This is indicated by lack of capacity, excessive evaporation and heating when charging.

Never test an accumulator with an *ammeter*. A storage cell will deliver a larger current than the ammeter will record. Always use the *voltmeter*.

SECTION IX — LUBRICANTS AND LUBRICATING

The purchaser of an automobile is usually cautioned about the oiling of a car but it is astonishing how many times this vital motor need is neglected. That the best automobile can be ruined in two hours by lack of lubrication is the conclusion of a dealer who has studied the problem of keeping the mechanism in perfect order. Oil prevents the shaft and bearing rubbing together—it "floats" the shaft, so to speak.

As a rule it is best to follow the advice of the maker of your car in regard to the kind of lubricants; however, some advice on the choice of oils is herewith given.

In selecting an oil, be careful to see that it has some little reputation in the motoring field. Unknown brands of oils are very apt to contain a large percentage of acid which sooner or later eats into the steel which is being lubricated.

For the cylinders use a mineral oil of high fire test. Cylinder lubrication is the most important of all automobile lubricating questions. A poor grade of cylinder oil will quickly ruin any gasoline motor. The high temperature of the cylinder wall averaging 250 degrees to 300 degrees Fahrenheit in an air-cooled engine and 180 degrees to 250 degrees in a water-cooled engine makes necessary oil that does not carbonize. Cylinder oil should be perfectly clear.

The same oil that lubricates the cylinders usually lubricates the main bearings on most cars. If grease is used for the shaft bearings, see that it is not of the cheap, soapy variety.

For the transmission gears an oil of fairly high viscosity is generally used. There being no high temperature

to be resisted by the lubricant, a cheaper grade of mineral oil may be used.

Very successful results have been obtained from the use of a heavy graphite grease in the transmission.

A petroleum jelly compound is the best lubricant for the ball or roller bearings supporting the axles of automobiles. Heavy steam engine cylinder oil is best for the differential case.

SUGGESTIONS

Use nothing but purely mineral oils—organic oils contain acid or other substances which have a harmful effect on the metal surfaces lubricated.

The force feed and gravity feed oilers are the universal oiling devices for multiple-cylinder vertical motors. After starting the car always see that the sight feeds show the oil drip and make sure the number of drops dripping correspond with the manufacturers' instructions.

If the engine seems to be working properly and yet the car shows a falling off in power, there is present, no doubt, abnormal friction. Overheating, which if present can be usually detected at the end of a run, is due to the same cause. In either case the oiling system should be thoroughly inspected. If the motorist familiarizes himself with the exertion required to crank the motor and push the car across the floor he will be in a position to instantly detect abnormal friction.

Do not endeavor to adjust a force feed oiler unless the oil is warm, for oil runs much slower when cold than when warm and an adjustment, made with cold oil gives too much when running on the road.

Should the engine smoke when running on the road, decrease the oil supply to cylinders continuing until smoking ceases. A period of running should precede each adjustment to make sure that any oil accumulated during the previous adjustment has had a chance to burn out.

The motorist is generally supplied with complete directions as regards the lubricating of his car—however, where these instructions are meagre, the following hints may be found useful.

About every two or three months, open all petcocks on bottom of crank case, thus letting oil drain from each compartment. Flush the case with gasoline and refill with clean oil until it begins to run out of petcocks, after which they should be closed.

Refill the transmission case whenever the supply gets below the gears.

See that universal joints are lubricated every two weeks or oftener if necessary.

About every two months replace oil in differential case.

The steering gear is usually packed in grease and needs attention about every two months.

SECTION X — CONCERNING COOLING SYSTEMS AND RADIATORS

The intense heat generated in the cylinder by the firing of the charge would make proper lubrication impossible unless some means were devised to keep the cylinder at a proper working temperature.

There are two methods of cooling the cylinder—air, or direct cooling and water, or indirect cooling.

Air-cooling is usually accomplished by means of flanges or gills cast on the cylinder or inserted pins or tubes, thus providing a large radiating surface. A forced draught of air is maintained by a fan driven by the engine for the purpose of increasing radiation with air currents at high speed.

An air-cooled motor usually uses more oil than one which is water-cooled, this excess of oil aiding materially the cooling process. In an air-cooling system there is little to get out of order. Occasional attention as to the tension of the fan belt is all that is necessary.

In water-cooling there are two methods of effecting the water circulation; the forced circulation system by means of a pump driven by the engine and the gravity or natural circulation in which the natural rising of heated water is relied upon to cause the circulation.

Both of these systems are efficient and are in general use.

The essential parts of a water-cooling system are the radiator, water jackets, pipe connections and a water pump if the forced circulation system is used. The water jackets surround the upper part of the cylinders and are cast both separately and integrally, that is the cylinder and jacket cast in one piece. Water is forced through the jacket by means of a pump or natural circulation as before described.

After passing through the jacket and becoming heated by the cylinder wall the water enters the radiator. The radiator is a device in which the water is cooled before it again enters the jacket, otherwise the water would soon become superheated, forming a large amount of steam which would result in a bursting of pipes or jacket. The water circulation commences when the motor is started.

The troubles experienced in the cooling system are mostly traceable to the radiator. Radiator troubles are mainly two in number—heating and leaking. A formation of an air or steam pocket, or trap in the water connections, would cause a stoppage of circulation. Sometimes when the engine is overheating, the radiator will be found to be perfectly cool. In an instance of this sort, it is safe to say the pump is not working or that the water is not going through the radiator, but is being by-passed at some point.

If, after stopping the car, the water boils for a minute or two, the radiator is probably a little too small for the car.

A geared pump, in stopping, of course stops the water flow and the still water in the cylinder jacket rapidly heats to the boiling point, producing steam and forcing water out of the overflow. Steam-venting the radiator intake pipe or water jackets overcomes this difficulty. Substituting a rotary pump also does away with the trouble by allowing a thermal circulation after the pump has stopped.

The danger from freezing can be obviated by following the instructions in Section XVII relative to anti-freezing compound.

A slight leak in the radiator may be stopped temporarily by throwing in a handful of bran or some like substance.

Honeycomb radiators with thin water spaces are apt to become clogged with lime deposits. A flushing out with steam and a little glycerine once a season will prevent this trouble. A solution of caustic soda will also thoroughly

cleanse the radiator. The proportion is 2 1-2 pounds to the gallon capacity of the cooling system, that is, if five gallons is the capacity of the cooling system, 12 1-2 pounds of caustic soda would have to be used. In determining the capacity of the cooling system, care should be taken to leave no water, which would have the effect of diluting the solution which is to take the place of the water. Caustic soda solutions should not be used if any part of the cooling system is of aluminum or zinc.

In touring it is well to carry a fine strainer for the radiator in case you are compelled to use water from some unclean source. A handkerchief will do if no strainer is at hand.

SECTION XI — CARE OF BRAKES

As the drum brake is universally used on automobiles we will deal only with this type. The brake drums are generally located on the rear wheel hubs, although many have in addition a drum on the transmission shaft.

As brakes are constantly wearing they require frequent adjustment. They should be carefully scrutinized before every run and given a thorough test at frequent intervals.

To make certain of proper adjustment, jack up car, fully release the brakes and turn wheel around slowly. When doing this be on the alert to detect any bind. This bind, called dragging of the brakes, would speedily result in burning out the band lining and in some instances so burning the wheel as to render it useless. When the brakes are fully set, it should be impossible to turn the wheel. First try the external contracting brakes, which are generally operated by a foot pedal, then the internal contracting brakes, operated by the hand or emergency lever, and finally test the driving shaft brake if there is one. The brake band on one wheel should act as strongly as that on the other. The safest way to test the brakes is to drive the car a short distance up a steep hill and see whether or not the brakes hold.

In order to secure full braking effort adjust the toggle link controlling the contracting and expanding of the brake band so that it is *nearly straight* when the brakes are *fully set.*

Reline brake bands when they give evidence of wear, thereby being prepared for any emergency.

Allow no oil or grease to remain on the brakes as this would prevent their holding. If any oil collects between the band and drum it may be quickly removed by gasoline, after which all parts should be carefully wiped with clean rags or waste.

Beginners in driving are cautioned to see that the emergency brake is released before starting the car, a thing that is easily forgotten and frequently done by experienced drivers.

The motorist should learn to judge the efficiency of the brakes every time that he applies them. In case either brake shows any lack of holding power, he should make an immediate investigation.

Be careful to secure such an adjustment as will cause the brake to be fully applied before the operating pedal or lever has reached the limit of its travel. Neglect of this may render the brake inefficient.

In driving use the foot brake—keep the emergency brake for the use its name implies. Further hints on brake operation may be found under Section XIII.

SECTION XII — THE STEERING GEER

The steering gear of an automobile requires but little attention. As a fault in this part of a machine's anatomy would in all probability mean instant destruction to the car as well as to the owner, manufacturers generally have so perfected the apparatus that it occasions little or no trouble. The gears are usually packed in grease and the directions for re-packing should be carefully observed. The average steering gear needs re-oiling at intervals of two months. The simplest way to refill with grease is by means of a squirt gun.

Any trouble with the steering gear rarely becomes serious at once. Steering gear accidents are most always a result of neglect of warning signs. Too much back-lash or play in the steering wheel is not to be commended, as it renders steering uncertain to the average motorist and is apt to devolop into more serious trouble. Take up back-lash when you experience any uncertainty in driving.

Any unnatural stiffness in the steering gear should be sufficient cause for an immediate investigation. In some instances this stiffness may be the result of a lack of proper lubrication in the knuckles or in the reducing gear. In others it may be due to some more serious cause, as the bending of the steering column causing the shaft to bind, or some loss of adjustment resulting in an improper meshing of the gears. The remedy in nearly every case can be easily and quickly applied. Lack of attention to these details, however, may cost the owner his life.

Taking into consideration the heavy shocks and constant vibration that the steering apparatus is exposed to, it is wonderful that derangements do not occur much more often than is the rule. It may be safely said, however, that it lies within the power of the motorist to prevent any serious trouble of this nature.

SECTION XIII—HOW TO DRIVE AN AUTOMOBILE

One has but to observe passing automobiles to note the preponderance of incorrect driving. No one thing, with the exception of faulty lubrication, causes so much deterioration in a motor-car as careless operation.

The following paragraphs, if put to practice, will enable the motorist to drive his car with the minimum of wear and tear.

Starting.—Before cranking motor, see that spark is retarded, otherwise a back-kick will result. Always start on the low speed—starting on higher speeds strains the motor. Let the clutch in gently. Throwing in the clutch suddenly is a common and very harmful practice. It not only imposes a great strain on the mechanism but causes heavy wear on tires. When the car is under headway, accelerate motor and shift quickly to second speed, thence to high. If motor refuses to start after continued cranking, follow process of elimination recommended for failure to start given in Section III.

Stopping.—Slow down before stopping, thus making necessary but slight braking effort with the consequent saving of brakes. Do not stop so close to the curb that the tires rub. This causes excessive wear on the weakest portion of the tire's surface. When stopping on the road for repairs bring the car to one side of the road, keeping clear of the thoroughfare.

Reversing.—Always bring the car to a full stop and wait a moment for the transmission gears to slow down before placing lever in reverse.

Gear Shifting.—In making gear shifts with the sliding gear transmission the principal point to be borne in mind is to make the shift quickly, thereby avoiding burring of gears. In changing from one gear to another, the motorist

should see that the car speed is proportionate to that of the engine in order to avoid the shock and strain that otherwise would be caused. For instance, when shifting from intermediate to high speed, the motor should be accelerated to bring up the speed of the car to about the speed it would be carried by the high gear, and when shifting back to intermediate the car should be allowed to slow down to a speed corresponding with the speed of the car on the intermediate gear. Sometimes the gears will not mesh. In this case a slight rocking movement of the car will usually put things to right.

Ascending Hills.—Upon approaching a hill, the speed should be increased and full power applied on the ascent, thus "rushing" or taking the hill on the high gear, otherwise, the car would slow down, making necessary a change of gears.

Some drivers make use of the following very harmful practice: If the car is seen to be unable to take the hill on the high gear, the clutch is thrown out just before the engine is stalled, the engine speeded up and the clutch let in again in order to avoid shifting to second speed. The engine is running at high speed and the car is barely moving, and the great shock and friction when the clutch takes hold results, in most instances, in the burning out of the clutch. In any case, however, the whole mechanism is subjected to a great strain.

Occasionally a hill will be encountered which is too steep to be taken entirely on the high gear. When nearing the summit the engine will begin to labor. If upon retarding the ignition slightly the engine still labors it is wise to shift to intermediate speed.

Descending Hills and Coasting.—Coasting or speeding down hill with the clutch thrown out is a very risky practice unless the motorist sees an unobstructed stretch at the bottom of the hill where the momentum of the car can

safely spend itself. When coasting the motorist is absolutely dependent on the brakes. He must either keep the brakes applied lightly during the descent or must depend upon a sudden braking to stop his fast-flying car. With the former, the constant throwing on and off of brakes causes abnormal wear of the brake shoes, and with the latter a sudden application of brakes when the car is moving fast invariably burns out the brakes, rendering them useless and resulting perhaps in a serious accident. When descending a hill with a rise or clear road at its foot it is well enough to throw out the clutch and coast, cutting out spark perhaps, thus allowing engine to cool. When the foot of the hill looks uncertain, however, the motorist should retard the spark and throttle and descend with the high gear in, or if hill is very steep with the intermediate gear in, thus using the compression of the motor as a brake. The car is then under instant control.

In case the car is coasting the switch should be closed and the clutch thrown in while the machine is under headway. Always use the high speed when applying the power in this manner.

Application of Brakes.—Make it a point to apply brakes easily. Sudden braking causes a great strain on the mechanism and heavy wear on tires. This is a common fault that can be easily remedied. Allow the car to slow down so that the braking effect required to produce a dead stop will be very slight. If the brake adjustment does not permit gradual braking see that it is changed.

Slipping Brakes.—Brakes very often slip or fail to hold the car on a hill. This failure, usually much dreaded by the novice, is not so serious as may be imagined. By shifting quickly to low speed and throwing off switch, the car will be held motionless or at least will move very slowly owing to the resistance of the motor compression.

Skidding.—This is a straight ahead or sidewise slipping

of the wheels due to wet or frozen road conditions. Skidding may be caused by turning the car quickly or applying brakes abruptly. The remedy is tire chains or a special tread on the rear wheels. Some motorists place one chain on the left rear wheel and the other on the right forward wheel, claiming it secures better traction.

Steering.—The principal point to be remembered in connection with steering is that but slight movements rather than distinct turns of the wheel are needed to guide the car. It is really the secret of good driving. On straight stretches of road, practically no steering wheel manipulation is needed—a slight steadying of the wheel keeps the car on a straight line. In turning corners one should make the turn gradual and not abrupt. Abrupt turns of the wheel render the guidance of the car more difficult. When rounding the corner acquire the habit of making a close turn—keeping on the side rather than in the middle of the road, thus practically eliminating the possibility of collision with vehicles coming in the opposite direction. This same rule applies with equal force when ascending small inverted V-shaped hills so often met with in the country, especially those with narrow roads. It is impossible for the motorist to see any vehicle ascending on the opposite side until he arrives at the top of the rise. Both cars are in all probability speeding to take the rise on high, and if both cars are in the middle of the road, consummate skill will be required to avoid a collision.

Continued Fast Driving.—This practice cannot be too severely condemned. It not only adds the factor of danger to motoring, but causes rapid wear and tear on the whole mechanism. Simply because a car can speed up to fifty miles per hour is no reason for driving continuously at that speed. The car's best speed should be made use of only in emergency, or if for other purposes only at intervals and for short duration.

Turning Corners.—Make a practice of turning corners at slow speed. The simplest method is to pull the throttle back just before the turn is reached, using but the momentum of the car in turning. Driving around turns at high speed causes excessive tire wear, imposes a heavy strain on the driving mechanism and has a tendency to pull the rear axle out of alignment, which would eventually become a serious matter on cars not possessing torsion or strut rods, which hold the rear axle always in perfect alignment.

Taking Obstructions on the Road.—In passing over thank-you-ma'ams, water bars, curbstones, and other obstructions, never allow the steering wheels to strike the obstructions squarely, as then the full force of the shock is imparted to the car. By taking them with a sidewise, twisting movement, first one steering wheel and then the other, the shock is broken and does no particular harm.

Continued Running on Low Speed.—This is usually practiced by beginners who do not have confidence to drive through crowded districts on high speed. It is perhaps the best thing to do under the circumstances, but the motorists should strive to resort to lower speeds only when compelled to do so. Constant running on the low gear causes overheating and has the same wear and tear effect of fast driving.

Racing Engine.—This consists of speeding the motor with the car stationary. It is a practice to be recommended only when absolutely necessary as in testing the carburetor or ignition.

Drivinz on Trolley Tracks.—This of course produces a smooth motion, but it is at the expense of the tires. It does not require a great length of time for the sharp edges of the track to cut the tread of the tire.

Crossing Railroad Tracks.—Many regrettable accidents have been the outcome of hurried crossing of unguarded

railroad tracks. If the track is visible for a considerable length in either direction, there is no need of stopping the car. If, on the other hand, there is a curve or siding of freight cars, the car should be stopped and the motorist should walk to the track and listen for any approaching train. It is the only safe way.

Crossing Streets.—The best method is to sound the horn, slow down and be prepared for a quick stop.

Passing Street Cars.—The motorist should be most careful in passing street cars. Always go slow, sound horn and be ready to stop instantly, as the many persons who step off the car walk around the end, coming suddenly in front of the motor-car.

Passing Vehicles.—Always pass vehicles headed in the same direction as the car on the left side. Do not wait until you are directly in the rear of the vehicle before beginning the turn out, but start the turn quite a distance behind, as this makes steering easier and more certain. In passing a horse headed toward the car it is the best policy to stop completely should the horse show signs of alarm. A horse headed in the same direction as the car should be passed quickly on the high gear. Always sound horn when about to pass, as often vehicles are apt to turn in a direction crosswise to the direction of the car.

Spark and Throttle Control.—The motorist should endeavor to control the car as much as possible by means of spark and throttle. This minimizes the necessity for gear-shifting and clutch manipulation, with the effect of eliminating the wear and tear on the driving system.

The brake may be used lightly to slow the car down to a slower speed than could be obtained by spark and throttle.

There is no particular harm in doing this moderately. At all events the wear on the brake would not amount to the wear occasioned by gear shifting.

SECTION XIV — HOW TO CLEAN AN AUTOMOBILE

All the equipment needed to wash a car thoroughly and perfectly is two large sponges, two chamois skins and a hose. One sponge and chamois skin should be used only on the body, the other set being for the wheels and running gear. Many motorists make the mistake of using but one sponge and chamois. More or less grease collects in the sponge used on the wheels and running gear, and when this sponge is used on the body, it gives the surface a cloudy and smeared appearance, which can be observed on many machines.

Therefore it is most important to possess two sets of sponges and chamois skins, which should be kept in separate places.

The car should be washed at the end of every run. Under no circumstances allow mud to remain on a car over night and harden, as by so doing the finish is given a spotted appearance which can be remedied only by a visit to the paint shop.

When the car is housed, play the hose (use a hose without nozzle) easily over the varnished surface. After a few minutes play the water hard so as to clear the surface of the heavy mud and grit. Do not *rub* it off with a sponge.

When the heavy coating of mud has been removed, go over the body with a sponge on which has been rubbed a generous quantity of castile soap or good automobile cleansing preparation. Clean the surface thoroughly, leaving no trace of dirt. Next rinse off with water before the soap has had time to dry. The final step is to dry the varnished surfaces thoroughly with the chamois.

Celluloid Fronts.—The surface and transparency of celluloid windows which have been scratched and dimmed by

use may be restored in the following manner: If the worn sheet is varnished on the worn side, or on both sides, if both sides are worn, with a very thin, even coat of any transparent varnish, it will recover practically its original condition and appearance. Probably the best varnish for the purpose is made by dissolving a quantity of transparent celluloid in acetone, making the solution exceedingly thin and applying more than one coat if necessary.

SECTION XV — HOW TO HANDLE A NEW CAR

A new car must be handled with a certain amount of care to insure the ultimate full development of power and ease of operation.

The car may be safely driven home under its own power. However, if the purchaser is a novice and the weather forbidding, he may decide to have it towed home so as to avoid any possible strain. In this instance, care should be taken in seeing that the tires are properly inflated and the clutch disengaged. The brakes should also be carefully tested and found to be working properly, otherwise, a regrettable accident may ensue. The tow rope should be sufficiently long to avoid the possibility of collision by a sudden stop of the vehicle towing, and should be attached to some substantial part of the machine—the springs or the front axle, providing there is no interference with the steering gear.

In preparing the car to be driven home under its own power, see that the gasoline tank and radiator are filled. It frequently happens that some parts of the car are removed or loosened by the manufacturer prior to shipping and the purchaser not informed, so that the car either cannot be started, or, if started, causes more or less trouble and even damage. This matter should be taken up with the manufacturers before shipment.

Start engine and speed it just a little to ascertain whether or not the ignition is correct. In case the motor runs smoothly without "skipping," the gear lever may be thrown into low speed and the car started.

A common and serious mistake made by many motorists is in speeding a new car. All its parts are more or less stiff, and driving at high speeds overheats the motor and

strains the mechanism generally. Scored cylinders and melted bearings are a frequent result of this practice. A new car should have more than the usual amount of oil.

SECTION XVI — THE CARE OF TIRES

The small mileage that many motorists get out of a set of tires is due almost wholly to carelessness or ignorance of their care. The principal causes of tire trouble are given herewith: Incorrect Driving, Exposure to Undue Light, Heat or Cold, Exposure to Oils and Grease, Incorrect Inflation, Excessive Weight and Improper Alignment of Steering Wheels.

Incorrect Driving.—Incorrect driving plays an important part in the destruction of tires. One of the chief causes of tire blow-outs is fast driving. The frictional heat generated is very great and should the tire be at all weak, continued speeding will result in the bursting of the fabric. Tires are put together by heat and heat will naturally separate the layers.

Turning corners at high speed is a fruitful cause of rim-cutting. This practice imposes an abnormal strain on the tire shoes, greatly lessening their life.

The skidding produced by a sudden application of brakes is very detrimental to the life of the tires. See Section XIII.

Another contributor to tire wear is the turning of the steering wheels when the car is standing still. Always let in the clutch gradually, as any sudden gripping of the clutch is transmitted to the tires.

A great amount of wear is caused by rubbing the wheel against the curbing when the car is brought to a stop. If this is of frequent occurrence it will quickly wear off the outer covering of the rubber at the point of contact. Water can then easily enter this abrasion, rotting the canvas underneath.

Effect of Light, Heat or Cold.—Excessive light, heat or

cold have a very injurious effect on rubber. The car should not be left standing for any length of time in any spot where the sun can beat down directly upon the tires. When the car is put up for the night, care should be taken to keep it away from radiators or steam-pipes. On the other hand, should the garage be improperly heated, the cold will be just as apt to dry and shrivel up the tires. When the car is put up for the winter, it is always advisable to have the tires removed and stored in a cool room, not exposed to direct sunlight, inflating them slightly to preserve their shape. Inner tubes should be kept in a moisture-proof bag in which a liberal amount of French chalk has been placed.

If the tires are to be left on the wheels, the car should be jacked up, otherwise the weight of the car will cause them to flatten. Each tire should be inflated slightly.

Oils, grease and rust should be carefully kept away from tires. Oil or grease is best removed with a dry cloth, after which some French chalk should be rubbed vigorously on the portions which were covered.

Effect of Rim Rusting.—Frequent inspection of the rims and bolts should be made to insure against accumulation of rust, which would ultimately reach and quickly rot the canvas. Any spots should be removed with emery and it is well to give the inside of the rim a coat of shellac.

Incorrect Inflation.—A train of tire troubles follow incorrect inflation. The novice usually inflates the tires insufficiently for fear of bursting them. This is an erroneous fear, as the ordinary pump is not capable of exercising a pressure sufficient to burst the tire.

Inflation troubles can be easily avoided by examining the tire where it touches the road. If the tire is too hard it will not show any depression under load. Should it be too soft it will appear to be carrying too heavy a load. When properly inflated it will settle or widen under the load about 1-8 inch for each inch of tire diameter. For instance,

a 3-inch tire under load should measure about 3 3-8 inches across the widest part at point of contact with the ground.

The tires should be inspected after every run and kept at the same degree of inflation. If this is done it will not only add to the life of the tire but will serve to warn the owner of any tire trouble, as small punctures and weak spots retain air under a certain pressure, only to cause trouble when the air pressure is raised.

Excessive Weight.—This fault will cause rapid destruction of the best tire. The following table gives the average weight per wheel that the various sizes of tires can bear safely:

Size	Weight Per Wheel
28 to 36 x 2½	225 lbs.
28 to 36 x 3	350 "
28 x 3½	400 "
30 x 3½	450 "
36 x 3½	600 "
34 x 3½	600 "
32 x 3½	550 "
30 x 4	550 "
32 x 4	650 "
34 x 4	700 "
36 x 4	750 "
32 x 4½	700 "
34 x 4½	900 "
36 x 4½	1,000 "

Improper Alignment of Wheels.—Looseness in the steering lever joints causes the front wheels to veer from their natural parallel track, resulting in causing the tread to rub over the road instead of rolling over it. The tires will wear in the same manner if the steering rod connection between the levers is too short or too long, as this causes the wheels to be thrown out of parallel.

Worn Tread.—As soon as the tread wears away sufficiently to expose the fabric, the tire should be immediately

removed and re-threaded. It will then be good for much more service.

Cuts.—Examine the tires at frequent intervals for cuts and gashes. If found, these should be thoroughly washed out with water (not gasoline or kerosene), dried and cemented. The tire should then be wound with tire tape and kept wound until the cement has had a chance to firmly set. If the cut is a large one it is best to have the tire vulcanized. Neglect of cuts is the cause of blowouts or blisters later on.

Washing Tires.—The best method of washing tires, according to an eminent tire authority, is by means of passing a damp sponge or well-wrung cloth around the covers. In this way all grit and dirt can be effectively removed and the condition of the tire seen. Never use kerosene or gasoline.

SECTION XVII—CARE OF THE CAR IN WINTER

The greatest winter danger is the freezing of the water in the cooling system. This invariably ruins the radiator and cylinders. Some motorists resort to the expedient of letting the motor run while the car is standing and drawing the water from the cooling system if the car is kept over night in a cold place. But this is poor policy, as it is wasteful of gasoline, entails useless wear on the motor and means considerable trouble for the motorist.

The easiest and safest method is to use a good anti-freezing solution. At the approach of cold weather and when there are indications of a temperature as low as 35 degrees F., all the water should be drained from the cooling system. This may be done by opening the petcock on the under side of the radiator and letting the water run out. If there is a cock on the water pump, open that also. When the water has been drained off, refill the radiator with the anti-freezing solution.

There are three kinds of anti-freezing solutions in general use—calcium chloride, glycerine, and wood alcohol. The following table shows the freezing points of different solutions of these fluids:

FREEZING TEMPERATURES FAHRENHEIT

Chemical	% Solution					
	10%	15%	20%	25%	40%	50%
Cal. Chloride . .	15°+	5°+	0°			
Wood Alcohol . .	15°+	5°+	2°+	0°	20°—	
Glycerine . . .	20°+	15°+	8°+	5°+		10°—

+ above 0° — below 0°

In using the high solutions of calcium chloride, there is danger of injuring the radiator as the fluid has a tendency to attack the solder. This may be remedied by placing a handful of quicklime in the solution.

The tendency of glycerine to congeal at very low temperatures is largely neutralized by adding a small quantity of sodium carbonate (washing soda) 2 per cent. by weight, to the glycerine solution. The heat of the engine will cause the wood alcohol to gradually evaporate, and more must be added at intervals. In the case of the calcium chloride, replace evaporation with clear water and leakage with solution. It is well to add a little glycerine to the wood alcohol solution as this enables it to resist a much lower temperature.

In the spring, when through with the anti-freezing solutions, the cooling system should be thoroughly cleansed. Open the drain cocks under pump and radiator and drain off the water. Now, leaving the cocks open, take off top of radiator and insert a hose attached to a continuous supply. Start the engine and continue running until the water issuing from the drain cocks is clear.

STORAGE OF THE CAR FOR THE WINTER

The place where the car is to be stored during the winter months should be kept at as even temperature as possible and should be free from dust and dirt. Undue heating or cold will cause the paint to crack and will dry up the tires. A car should never be placed near a stove or radiator or a cluster of steam pipes. If this is unavoidable, place an asbestos sheet between the source of heat and the car. For winter care of tires see Section XVI.

It is best to drain all water from the cooling system whether or not an anti-freezing solution is used, as the water would ultimately rust the interior of the jackets and would

be very apt to cause circulatory trouble when the car is started in the spring.

The gasoline tank should be emptied to avoid any fire danger. The entire lubricating system should also be emptied, as the oil is very likely to thicken and gum, causing trouble in the spring. Pour a little kerosene in each cylinder. It is not necessary to remove the spark plugs.

SECTION XVIII — CARE OF ACETYLENE LAMPS AND GENERATORS

Acetylene lamps use acetylene gas (C_2H_2), colorless and with a disagreeable odor. This gas is rapidly given off when calcium carbide, or some preparation thereof is brought into contact with water.

There are two systems of generating the gas in general use today: the drip system in which the water drops from the tank on to the carbide; and the compensating system in which the water is led from the tank by a pipe to the bottom of the generator.

The aim of any system of generating acetylene is to obtain a regular and unvarying supply of gas with the minimum consumption of carbide.

The generator consists of four essential parts: the carbide chamber, in which the fuel is stored; the water chamber, connecting with it and supplying the water; the gas chamber, which is often part of the other chambers, in which the gas collects after being generated; and the combustion chamber, in which air is mixed with the gas by means of a special burner and is consumed.

Water and fresh carbide then are the essentials for the production of acetylene gas. The passage from the water to the carbide must be free—a defect in the valve or other device controlling the water supply is the cause of many lamps failing to work. Providing the water reaches the carbide in the desired quantity, we may look for trouble in the burner or tube leading to it. Both of these should be cleaned, being careful not to increase in size the little passages of the former when cleaning. Use a very fine hard brass wire in cleaning the burner. Always carry several spare burners so that the old burner can be replaced when it shows signs of trouble or any tendency to smoke,

and cleaned at leisure. The burner may be also cleaned by air pressure obtained by attaching it to the tire pump.

At the approach of cold weather brine should be substituted for water in the lamp, but it should be made from pure sodium chloride, free from magnesium chloride, the latter acting on metals and being often present in common salt.

The strong odor of acetylene will enable the motorist to quickly detect leaks. Leaks are most apt to occur around the generator gasket and at the rubber connections of the lamps. If lamp lights up quickly with a yellowish flame, it indicates a leak. When the system is working properly, the light should start up slowly with a slight hissing noise and a clear white flame. The silver reflectors should be kept scrupulously clean—a slight film of dust will greatly affect the reflecting power.

In rainy and muddy weather cover lamps with waterproof covers.

Always carry a reserve supply of carbide in an air-tight tin, several new burners, and some of the fine brass wire for cleaning burners.

SECTION XIX—HANDLING AND STORING GASOLINE

Gasoline by itself is not dangerous. But its vapor mixing with air forms a violent explosive, and it is this fact that necessitates care in handling and storing it.

Undoubtedly the best way to store gasoline is by means of the underground steel tank. The tank may be buried in any convenient spot near the garage, piped to inside of the building and the pump installed. The more expensive outfits are equipped with pump and automatic measuring devices. The gasoline may also be drawn by gravity or by air pressure.

In handling gasoline it is as important to keep it away from the atmosphere as it is to keep it away from the naked flame. Ignition of the liquid results in a fire; ignition of the vapor results in an explosion.

Don't leave half filled gasoline cans lying around and see that the gasoline is shut off on the car before leaving the garage.

Use no open flame lights in the garage and see that the electric wiring is insulated with extra care. The latter is a fruitful source of danger. See that no oil-soaked waste or rags are lying around.

In spite of every precaution there is apt to be more or less gasoline vapor in the garage. To remove any possibility of spontaneous combustion there should be an opening somewhere in the floor to allow this vapor, which is heavier than air, to sink and pass out.

Should a gasoline fire start do not use water in hopes of quenching it. It only makes matters worse. Sand, salt or some dry chemical extinguisher is the proper thing. A lap-robe or blanket is also effectual in an emergency.

Make a practice of filling both car and supply tanks by daylight.

A little care and thought in handling and storing gasoline will preclude danger from fire or explosion.

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